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A WET-DRY APPLE BIN FILLER

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ABSTRACT

This report describes a method for delivering apples into bins, the development of a full-scale prototype, and the testing of the prototype to assess its characteristics relative to a commercial packing operation. The new bin filler, designated as the "wet-dry apple bin filler," is either equal or superior to existing fillers. It is gentle on the fruit (as are existing hydrofillers); it fills bins quickly with a consistent uniform volume of apples; and it requires less space and less water than hydrofillers. The new filler also has a certain flexibility which allows for alternative layouts. However, this new filler could operate only in plants using a uniform bin size, which is also true for existing bin fillers.

All the testing to date was with apples, but the wet-dry apple bin filler could be adapted for other fruits.

KEYWORDS: Fruit, Apples, Handling, Filling, Bins, Packing

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A WET-DRY APPLE BIN FILLER

By S. W. Burt, G. E. Yost, and G. O. Patchen[1]

INTRODUCTION

Rapidly increasing costs for apple storage and packing are causing operators to change traditional methods of holding fruit in storage. Current procedures for controlling the atmosphere, temperature, and humidity of storage rooms within very close tolerances are costly; thus, storing orchard-run fruit containing culls is no longer feasible. Since it is impossible to pack all apples at harvesttime, those apples that cannot be packed should be sorted and sized, returned to bins, and stored separately for later packing. Inventory control becomes manageable and marketing and packing operations can become more efficient by storing fruit according to grade and size.

Apples in the Northwest are normally stored in bins 47 inches square by 24 inches deep. Packinghouse operators need a way to fill these bins that will keep apple bruising acceptably low, maintain a rapid rate of fill, utilize the maximum capacity of each bin, and occupy minimum space at a cost the medium and smaller volume packers can afford.

PRESENT METHODS

A dry filler has been available for some time and is standard equipment for putting cull and processor grade apples into bins. The time it takes to fill a bin with this filler is set by the rate of feed from the grader, size of apples, and speed and width of the conveyor belts. Time studies of filling operations show that a dry filler, as shown in figure 1*C*, requires about 6 minutes to fill a bin with apples, remove the full bin, and replace it with an empty bin. Bruise studies show that the dry filler tested inflicted grade-lowering bruises on as much as 34 percent of the apples, making it unacceptable as a method of filling graded and sized apples into bins.

Two different types of hydrofillers are used in the Northwest. With both systems, apples are delivered in water to the filler and do not leave the water until a submerged bin rises from the bottom of the accumulator tank, encompasses the fruit, and removes it from the water. In one case (fig. 1*B*), apples flow into the filling collar from above, and in the other (fig. 1*A*), apples are delivered under water by a rapid current and float up into the collar. With both hydrofillers, a bin full of apples is premeasured in an accumulator tank, and moving water carries the fruit to the filling collar. The time required to fill a bin is governed by the time required to raise a full bin from beneath the apples and replace it with an empty bin (about 1.2 min), plus the time for apples to flow into the filling collar. Total time for this operation ranges from 3 to 4.5 min.

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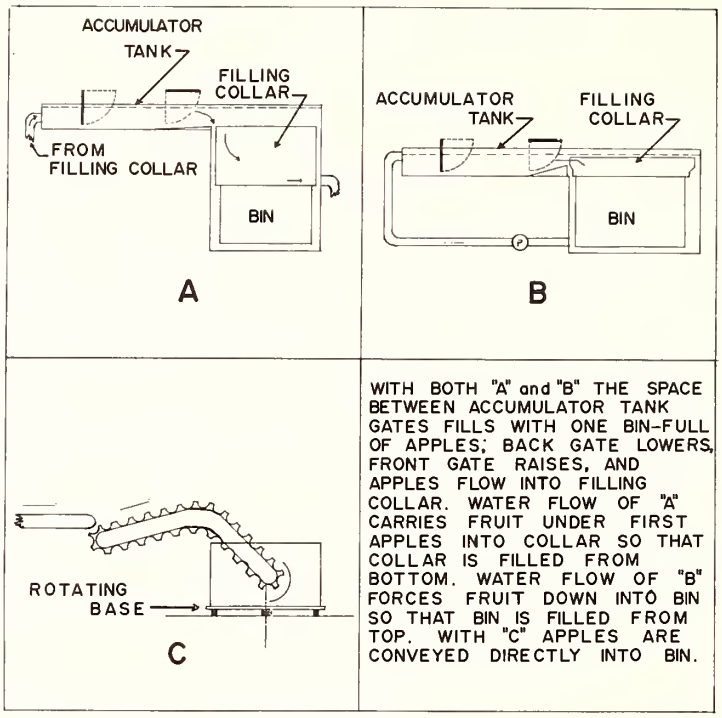
ACCUMULATOR TANK
FILLING COLLAR
FROM FILLING COLLAR
BIN
A
ACCUMULATOR TANK
FILLING COLLAR
BIN
B
ROTATING BASE
C
WITH BOTH "A" and "B" THE SPACE BETWEEN ACCUMULATOR TANK GATES FILLS WITH ONE BIN-FULL OF APPLES; BACK GATE LOWERS, FRONT GATE RAISES, AND APPLES FLOW INTO FILLING COLLAR. WATER FLOW OF "A" CARRIES FRUIT UNDER FIRST APPLES INTO COLLAR SO THAT COLLAR IS FILLED FROM BOTTOM. WATER FLOW OF "B" FORCES FRUIT DOWN INTO BIN SO THAT BIN IS FILLED FROM TOP. WITH "C" APPLES ARE CONVEYED DIRECTLY INTO BIN.

Figure 1.--Three different bin fillers in current use.

The major advantage of hydrofilling is that the fruit suffers very little damage. The major disadvantages are: (1) Density of fill is less than when dry filled;[2] (2) a large floor area is required by accumulator tanks; (3) large volumes of water are necessary; and (4) relatively high capital costs are incurred.

CONCEPT OF WET-DRY BIN FILLER

The wet-dry bin filler, as conceived, would combine the hydrofillers' gentle way of conveying and accumulating apples with the small space requirement and fuller fill of the dry method. To fulfill its objectives, the wet-dry filler must: (1) Have a low level of bruising; (2) fill the bin quickly; (3) occupy a minimum of space; (4) permit any number of units to be installed; (5) provide a full, uniform fill; and (6) be low enough in cost to make it available to a wide range of packinghouse operators.

Design of the wet-dry filler is based on the principle of a traveling crane, consisting of a frame on which a carriage travels laterally from the filling area of the tank to an adjacent bin, a basket to pick up apples from the filling area and deposit them in a bin, and gates either to hang vertically from the basket or to close to form a bottom to the basket. Auxilliary equipment consists of a tank with pump for continuous circulation of water and a positioner for the bin.

A preliminary working model of the basket with gates was constructed to test the effect of this new handling method on apples and to gain basic design data. Apples are introduced into a tank of water, and the basket--with its gates vertical--is lowered down through them. When submerged below the apples,

[2]Dewey, D. H., A. Stout, R. H. Matthews, R. W. Bakker-Arkema, and Joseph F. Herrick, Jr. Development of a hydrohandling system for sorting and sizing apples for storage in pallet boxes. U.S. Dept. Agr. Market. Res. Rpt. 743, 31 pp. 1966.

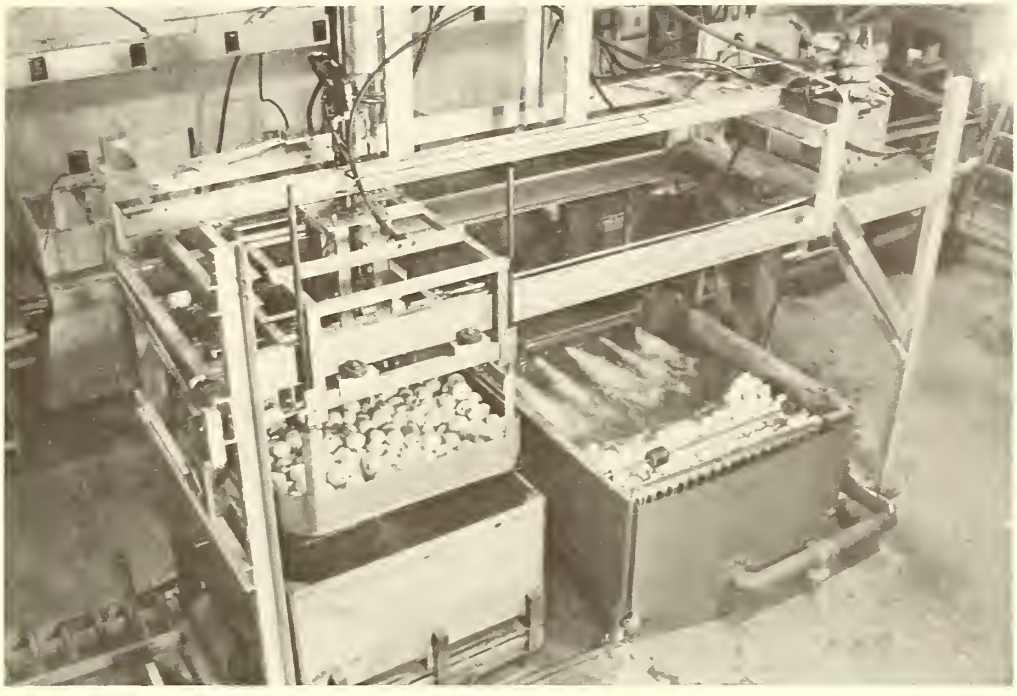

Figure 2.--Overall view of prototype wet-dry bin filler.

the gates are closed, and the basket is lifted out of the tank with a load of apples resting on the horizontal gates. The basket is then lowered into a nearby box, and the gates are released to hang free. As the basket is lifted from the box, the gates slide out from under the apples, leaving the apples in the box.

Tests with the model indicate that very little bruising occurs when the basket and gates descend through the apples or when the gates withdraw from under the apples. We also discovered that a distance of at least 8 inches between gates is necessary to prevent apples from bridging from one gate to another. Results of tests with the model suggested that we should go ahead with a full-scale prototype.

DESIGN AND OPERATION OF PROTOTYPE BIN FILLER

Basic components of the filler consist of a system for accumulating and layering fruit, a method for transferring fruit from the tank to a bin, a bin positioner and rotator, and a control and power system.

Accumulating Fruit

The prototype wet-dry bin filler is shown in figure 2. (In a commercial operation, apples would be delivered to the filler after sorting and sizing.) The fruit, already in water, moves to the accumulating and filling areas by water current. In the accumulator section, apples are only one-layer deep, and the current speed is only great enough to keep fruit from backing up in the tank.

The first trials with the prototype bin filler involved removing one layer of apples at a time and transferring them to a bin; however, the time required

Figure 3.--Water jets holding apples in filling area. Mechanism for signaling basket to descend is behind diverter on far side of tank.

to fill a bin this way is prohibitive. This problem is overcome by forcing the apples, by water pressure, to layer in the filling area to a depth of 6 inches (one-quarter of a bin full, or 200 lb). Water pressure is from five water jets--evenly spaced and at surface level--across the tank, 8 inches from where the basket descends into the tank (fig. 3). The closed water circulation system consists of tank, pump, control valve, and jets. The depth to which apples layer in the filling area is determined by rate of water flow from the jets. A valve in the line permits a fine adjustment. The filling area is 24 inches deep, 55½ inches wide, and 54 inches long, and the sides are lined with 2-inch polyethylene padding. The entire tank (filling area and accumulator together) is 7 feet long, and the water level is maintained at 19 inches.

Transferring Apples to Bin

If there are not enough apples in the filling area to constitute a full load, the carriage--with the basket retracted--comes to rest directly over the filling area and remains there until it receives a signal that a full load is in the filler tank.

The mechanism that signals a full load is located on the side of the tank next to a water jet (fig. 3). This mechanism activates a switch when an apple pushes against it. This happens when the filling area is full and fruit backs up past the jets. When the switch closes, the timer (which controls the sequence and time of each operation) is activated and signals for the basket to descend.

With its gates hanging vertical, the basket lowers through the apples until its bottom edge is beneath the lowest apples (fig. 4). The timer then signals the gates to close. The gates are closed by a hydraulic actuating cylinder with

mechanical linkage, which operates the gates through a 90° arc. After the gates close, forming a bottom for the basket, the timer signals the lifting cylinder to raise the basket from the filling areas; the basket rises, and the captive apples are lifted from the tank with it. Holes in the gates permit water to escape, and stabilizing rollers across the tank guide the basket in its ascent. When the basket is clear of the tank (fig. 5), the timer signals the carriage hydraulic cylinder to push the carriage and loaded basket from above the tank to a position over the adjacent bin. At the end of the travel, the carriage is di-

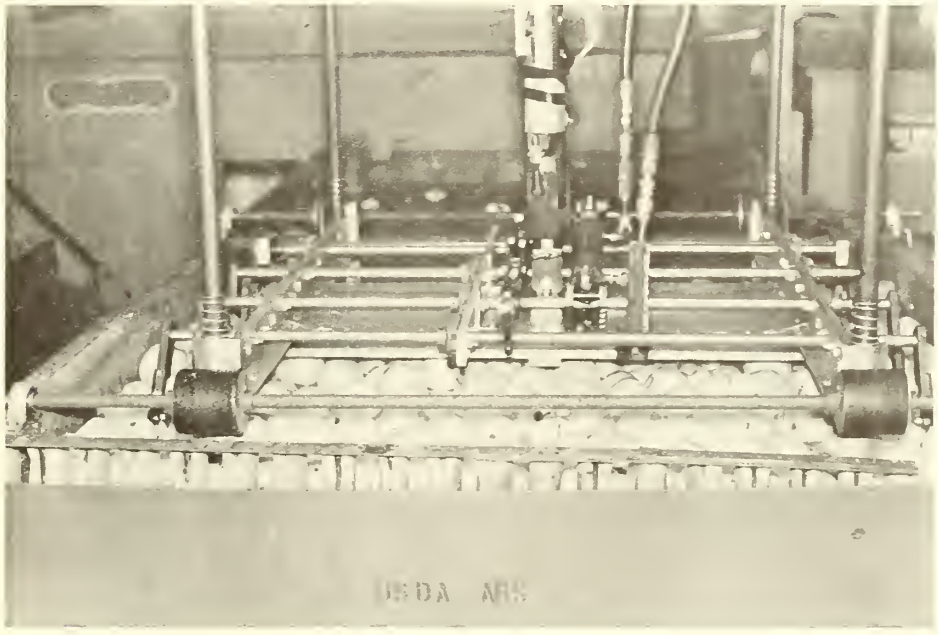

Figure 4.--Lowest position of basket and gates in filling area.

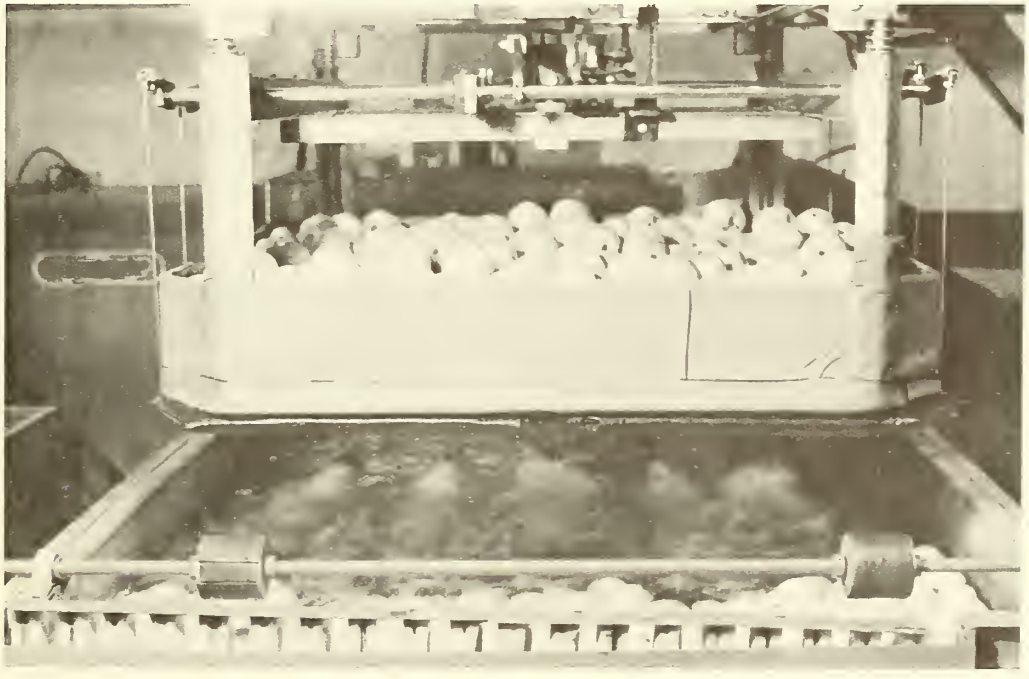

Figure 5.--Basket with 200 lb of apples poised to start travel toward bin.

rectly over the bin that is being filled (fig. 6). At this point, the timer signals the lifting cylinder to lower the basket slowly into the bin.

Because the basket is free-hanging from the lifting cylinder, its descent into the bin must be controlled because if the basket were to swing, tilt, or turn, it would catch on the bin edge. To direct the basket into the bin, a guide rod is attached to each basket corner, and each rod travels through a tube attached to the carriage.

Upon receiving its signal from the timer, the basket lowers slowly into the

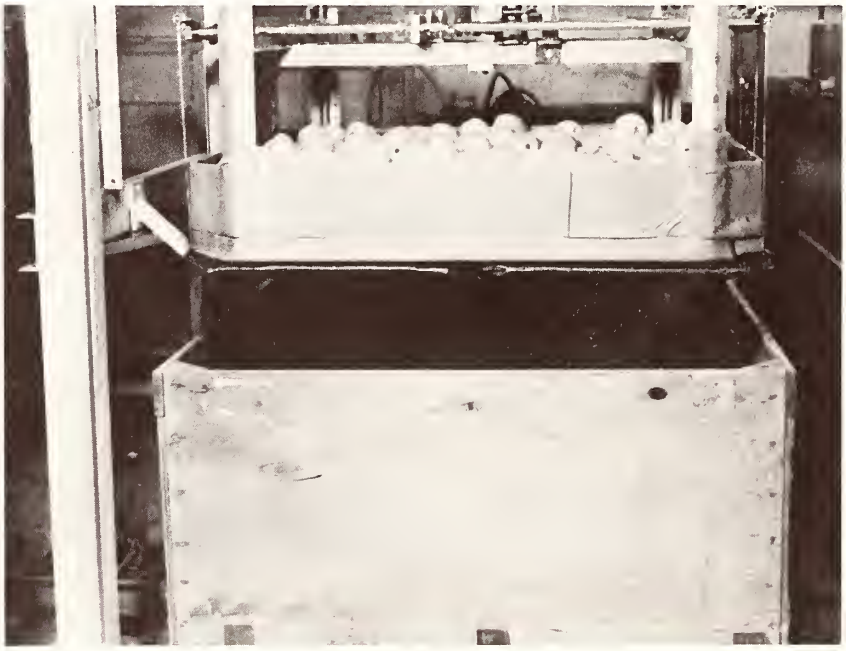

Figure 6.--Full basket in position to begin descent into bin.

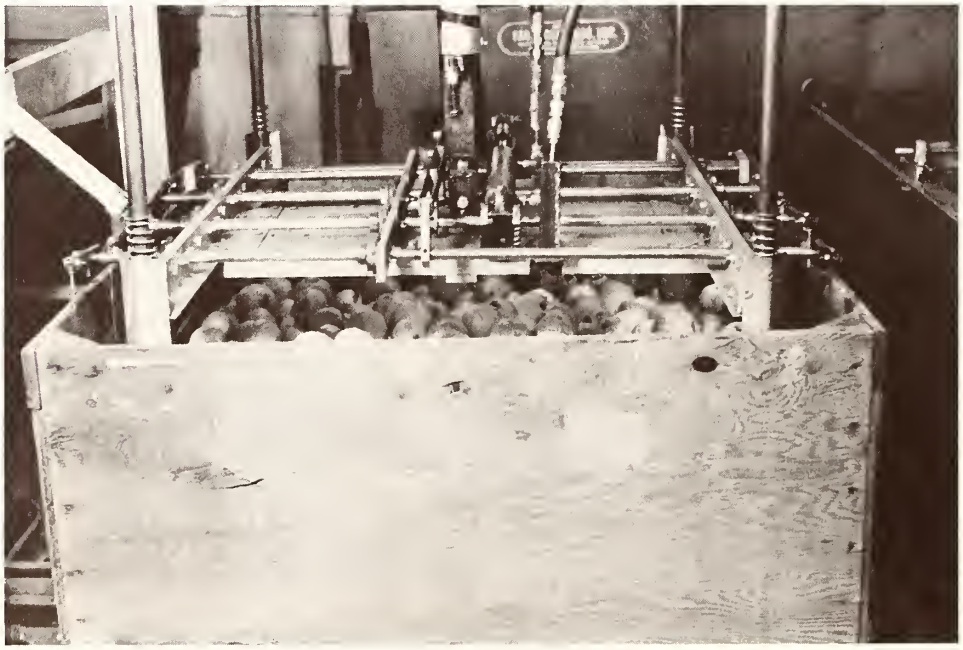

Figure 7.--Full basket hanging suspended in bin after "sensing" resistance and stopping descent.

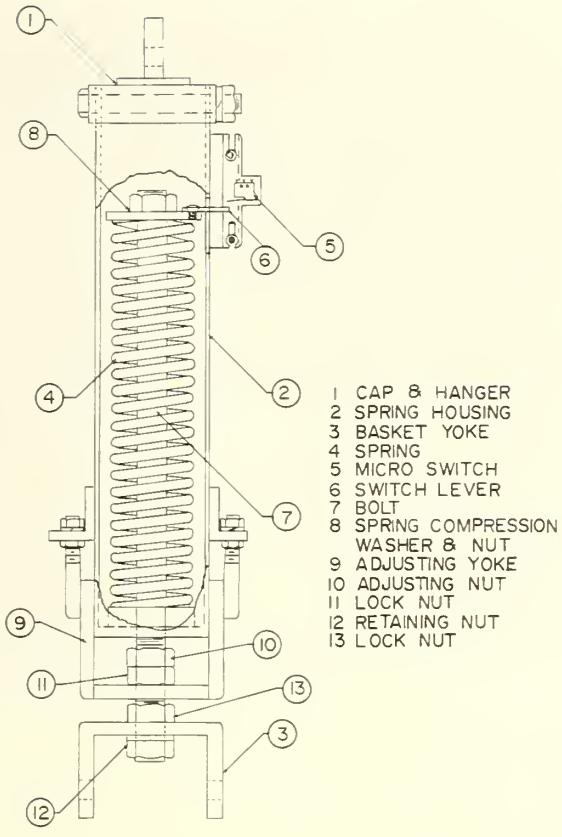

Figure 8.--Device for sensing when full basket should stop in a bin.

bin with the speed of descent governed by a flow-control valve in the hydraulic line. Upon encountering resistance (preset at 50 lb), the circuit actuating the descent is broken, closing the hydraulic valve and stopping the descent of the basket (fig. 7).

The device for stopping the basket descent is shown in figure 8. When upward pressure is applied to the basket, a precompressed spring flexes, tripping a microswitch, which breaks the circuit. This arrangement makes the entire underside of the basket and closed gates a sensor, which signals to stop the descent when either the bottom of the bin or the highest apple in the bin is encountered. When this happens, the basket hangs suspended until the timer signals the gate-control cylinder to release the gates. Immediately following, the timer signals the lifting cylinder to raise the basket from the bin. As the basket rises, the gates pull out from under the apples, leaving them in the bin. When the basket is fully retracted, the timer signals the carriage cylinder to return the carriage to a position over the tank, where it comes to rest until the timer is again activated.

Positioning, Rotating, and Replacing Bin

Because the basket enters the bin with little clearance, each bin must be properly positioned. The arrangement for doing this with the prototype wet-dry bin filler is shown in figure 9. Although this positioning works well for the purpose, it is not satisfactory for a commercial operation. The method shown

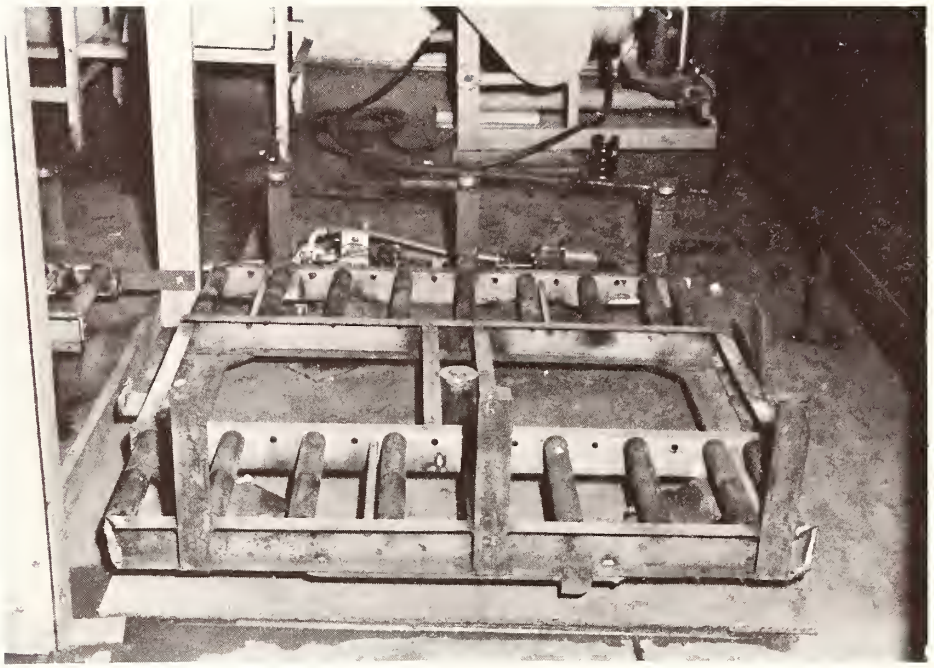

Figure 9.--Bin rotator used with prototype wet-dry bin filler.

requires an attendant to manually remove the full bin and replace it with an empty one. Commercial equipment already exists for doing this automatically.

Four basketfuls of apples will fill a bin. After the delivery of each basket, the bin rotates 90°. This insures a more uniform fill of fruit within the bin. After the fourth trip, the full bin is removed and replaced. This exchange of a full bin for an empty one takes place while the bin filler is performing other operations, and no separate time is allotted for it.

Controls and Power System

The wet-dry bin filler is powered hydraulically with the sequence and length of each operation controlled by a cycle timer (fig. 10). The hydraulic system is diagramed in figure 11. Three separate cylinders operate (1) the opening and closing of the gates, (2) the translation of the carriage between the bin and filling area, and (3) the lowering and raising of the basket. A flow-control valve in the line of the latter cylinder causes the basket to lower into the bin at a slower rate than that at which it enters into the tank. Electrical power supplying the timer, hydraulic pump, and valves is 115 volts at 60 Hertz. The timer is a standard eight-contact cycle timer set to complete one cycle in 37.2 seconds. Although the prototype filler is powered hydraulically, electric motors could be used.

The bin sits on a conveyor, which is mounted on a ring supported by a center pin and three wheels 120° apart. One is a drive wheel powered by a gear-head motor. The signal to rotate comes from a "push" switch mounted on the frame. When the carriage is over the bin, the switch is depressed. When the carriage moves towards the tank, the switch is released, and this signals the rotator motor to start. When the bin has rotated 90°, a dog on the ring trips a cutout arm, stopping the rotator. Automatic removal of full bins and their replacement with empties could be incorporated into the system.

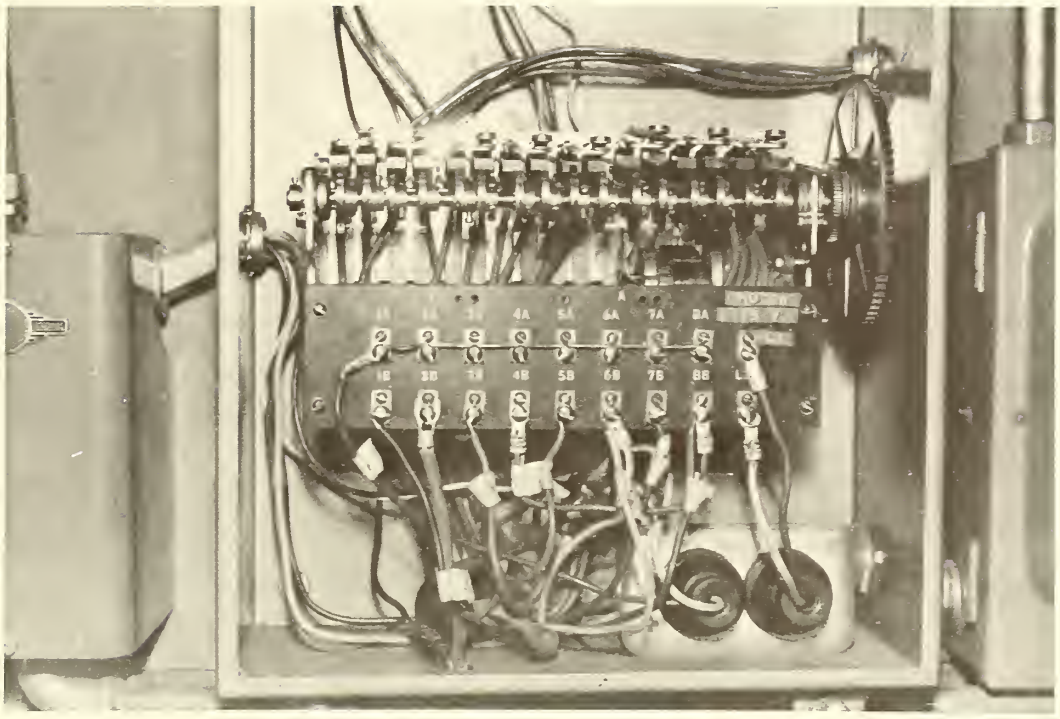

Figure 10.--Cycle timer, which controls time and sequence of operations.

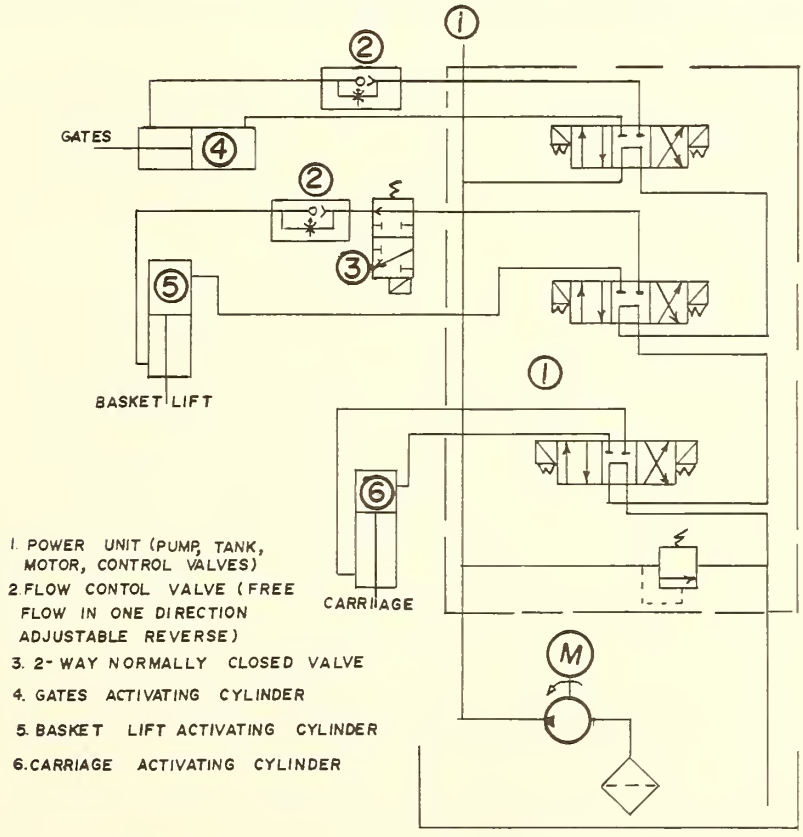
GATES
BASKET LIFT
CARRIAGE
M
1. POWER UNIT (PUMP, TANK, MOTOR, CONTROL VALVES)
2. FLOW CONTOL VALVE (FREE FLOW IN ONE DIRECTION ADJUSTABLE REVERSE)
3. 2-WAY NORMALLY CLOSED VALVE
4. GATES ACTIVATING CYLINDER
5. BASKET LIFT ACTIVATING CYLINDER
6. CARRIAGE ACTIVATING CYLINDER

Figure 11.--Hydraulic system used to power wet-dry bin filler.

RESULTS OF TESTS ON PROTOTYPE BIN FILLER

Tests were conducted on the wet-dry bin filler to determine the amount of bruising inflicted on fruit, the time required to fill a bin, and the fullness and uniformity of fill.

Bruising

Bruise tests were conducted in both 1974 and 1975. After the 1974 tests, the bin filler was modified in the following ways: (1) The inside of the filling area was padded; (2) the gates were strengthened and more padding was added; and (3) the speed of basket descent into the bin was reduced. Except for these changes, the machine was the same during both testing periods, and the tests were conducted the same way. All bruise testing was done with Golden Delicious apples. Cartons of apples in trays were brought out of storage, each apple was examined, and all bruises were marked with a felttip pen. As filler apples (also Goldens but not marked) were put into the tank, marked fruit was carefully placed among them, by hand, in a ratio of about 1 to 10. The apples randomly mingled and flowed in to the filling area. Bin filling took place as previously described. After the bin was filled, it was removed from the rotator, weighed, and placed in a submersion dumper. As the test fruits floated out, they were recovered and placed in trays and cartons. These cartons, along with check fruit, were stored at 34° F for 7 days and then examined for bruising. Bruises were scored according to official Washington State Grade Standards (table 1). After the apples had been separated according to bruises, State Inspectors examined the fruit and verified the classification based on bruising only.[3] Results of bruise tests are shown in table 2.

In 1974, 91 percent, and in 1975, 94 percent of the test fruit suffered either no injury at all or an injury too small to affect the grade. Seven and four percent, respectively, suffered grade lowering damage, and in each year two percent became culls. Of these culls, 1.7 percent were due to stem punctures. Samples from each lot were pressure tested, but the softness or firmness of the fruit did not appear to be a major factor in the amount of bruising that appeared.

In January 1976, an independent bruise study was conducted by scientists from a Canadian research station.[4] Their particular interest was in the amount and severity of damage inflicted by the wet-dry bin filler on McIntosh and Golden Delicious apples grown in Canada. Their test involved five replicates for each variety, with approximately 400 Golden Delicious and 300 McIntosh in each replicate. All fruit was examined carefully, and bruises and stem punctures were marked before the tests were conducted. The test fruit was manually placed into the water of the tank among filler fruit and was recovered when the full bin was submersion dumped. After damage assessment on the McIntosh, the replicates were combined and rerun as a bin lot to reevaluate incidence of stem punctures. Only 1.4 percent of the Golden Delicious had sufficient bruising to affect grade, and only one apple in 1,617 McIntosh was bruised to this extent (table 3).

[3]Our thanks to C. O. Von Essen and W. E. Hall, Washington State Department of Agriculture, Division of Plant Industry, for their assistance in evaluating bruise test results.

[4]We thank S. W. Porritt, Pomology Section, Agriculture Canada Research Station, Summerland, British Columbia, for permission to publish results of these tests conducted under his supervision.

Table 1.--*Scoring bruises on apples on the basis of Washington, Oregon, and Idaho State grades and U.S. grades*[1]

Grades	Type of pack[2]	Scorable when bruising affects more than[3]-- Depth	Area
		Inch	*Inches*
Washington extra fancy (all varieties)[4] U.S. extra fancy Idaho extra fancy (all varieties) Oregon extra fancy	All packs	1/8	1/2
Washington fancy (all varieties)[5] U.S. fancy U.S. No. 1 Idaho extra fancy (all varieties) Oregon fancy	Tray or cell	3/16	3/4
	Other packs	3/16	7/8
Washington C grades (green or yellow varieties) Washington summer fancy U.S. utility Idaho C grade (all varieties) Oregon C grade	Tray or cell	3/8	7/8
	Other packs	3/8	1-1/4

[1]Information taken from BN 33-2, August 7, 1967.
[2]Based on sizes 125 to 163.
[3]All soft bruises are scorable by Washington State Grade Standards.
[4]Includes Washington summer extra fancy.
[5]Does not include summer apples.

Time to Fill Bin

The wet-dry bin filler completes a cycle in 37.2 seconds, with time alloted as shown in table 4. This is operating time only and does not include time that the basket is waiting for a signal to lower through the apples. Because four trips are required to fill a bin, total filling time is 2.48 min, or 2 min 29 sec. This period includes the time required to exchange a full bin for an empty one, because this operation would occur simultaneously with the "travel horizontally empty" through "travel horizontally with load" operations.

Table 2.--*Bruising caused by wet-dry bin filling (Golden Delicious Apples)*[1]

Test dates	Apples tested	Pressure test	Apples bruised			
			None[2]	Extra fancy	Fancy	C grade[3]
1974	*Number*	*Pounds*	*Percent*	*Percent*	*Percent*	*Percent*
Oct. 18	237	16.0	70	23	5	2
Dec. 30	246	13.0	70	20	8	2
Average 1974[4]		14.5	70	21	7	2
1975						
Nov. 11	587	12.5	70	24	5	1
12	465	12.5	69	26	3	2
21	1,219	12.0	77	18	3	2
Average 1975[5]		12.2	73	21	4	2

[1]Based on Washington State Grade Standards.
[2]Extra fancy with no discernible bruise.
[3]1.7 percent were stem punctured.
[4]Four replications.
[5]Nine replications.

Table 3.--*Bruising from wet-dry bin filler (Golden Delicious and McIntosh from Canada)*

	Apples tested	Pressure test	Apples bruised				
			None	1/4" bruise aggregate	1/2" bruise aggregate	3/4" bruise aggregate	1" bruise aggregate
	Number	*Pounds*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Golden Delicious	1,899[1]	13.1	64.8	25.3	7.5	0.9	0.5
McIntosh	1,617[2]	11.5	89.7	9.8	.6	.0	.1

[1]1.21 percent were stem punctured.
[2]1.86 percent were stem punctured.

Table 4.--*Cycle time for wet-dry bin filler*[1]

Sequence number	Operation description	Cycle time
		Seconds
1	Travel horizontally with load	5.4
2	Lower basket into bin	7.8
3	Release gates	1.2
4	Raise basket out of bin	4.2
5	Travel horizontally empty	3.6
6	Lower basket into tank	6.0
7	Close gates	4.8
8	Raise basket out of tank	4.2
	Total time	37.2

[1]Four cycles equal one binfull.

Fullness and Uniformity of Fill

A consistently uniform, full bin results when the water level in the tank and the water pressure holding apples in the filling area are held constant. A typical fill pattern is shown in figure 12. Several bins of Goldens were weighed and consistently netted 800 lb plus or minus 20 lb. Density of fruit varies with the variety and must be adjusted for by changing the water pressure. Apples tended to mound somewhat in the center and to be lower in the corners.

Figure 12.--Typical fill pattern using wet-dry bin filler.

CONCLUSIONS

The testing program indicates that the new concept embodied in the wet-dry bin filler fulfills the objectives that were set for it. The new filler fills bins with approximately the same level of bruising as hydrofillers. It fills bins quickly and consistently with a full uniform load of apples, requires about one-quarter the space and water of hydrofillers, will fit into existing packing houses with a minimum of alterations, and its cost should not be prohibitive. Its limitation is that bins used with it must have the same dimensions and not be racked or warped, for the basket must be able to descend into them.

In a commercial pregrading operation, a separate tank would be necessary for each grade and size, but one carriage basket combination could, within limits, serve any number of tanks. Figure 13 shows a possible three-tank arrangement, with single carriage basket unit traveling the length of the frame, going to whichever tank signals that its filling area is full. A control system for this three-tank unit has been designed, and by adding control modules, additional tanks could be put on line. At some point, the single carriage basket could not keep up with the volume and another would be added, with each carriage basket traveling on the same frame but serving only its assigned tanks.

The wet-dry bin filler permits some flexibility in layout. Figures 14 and 15 are two possible 12-tank layouts--one for a long, narrow building and one for a short, wide building. In each case, empty bins would be supplied by a conveyor running under the accumulator section of the tank where apples flow only one-layer deep. Other arrangements are possible. Technology for automatically removing full bins and replacing them with empty bins is already available, but this more sophisticated system was not incorporated into the experimental prototype bin filler.

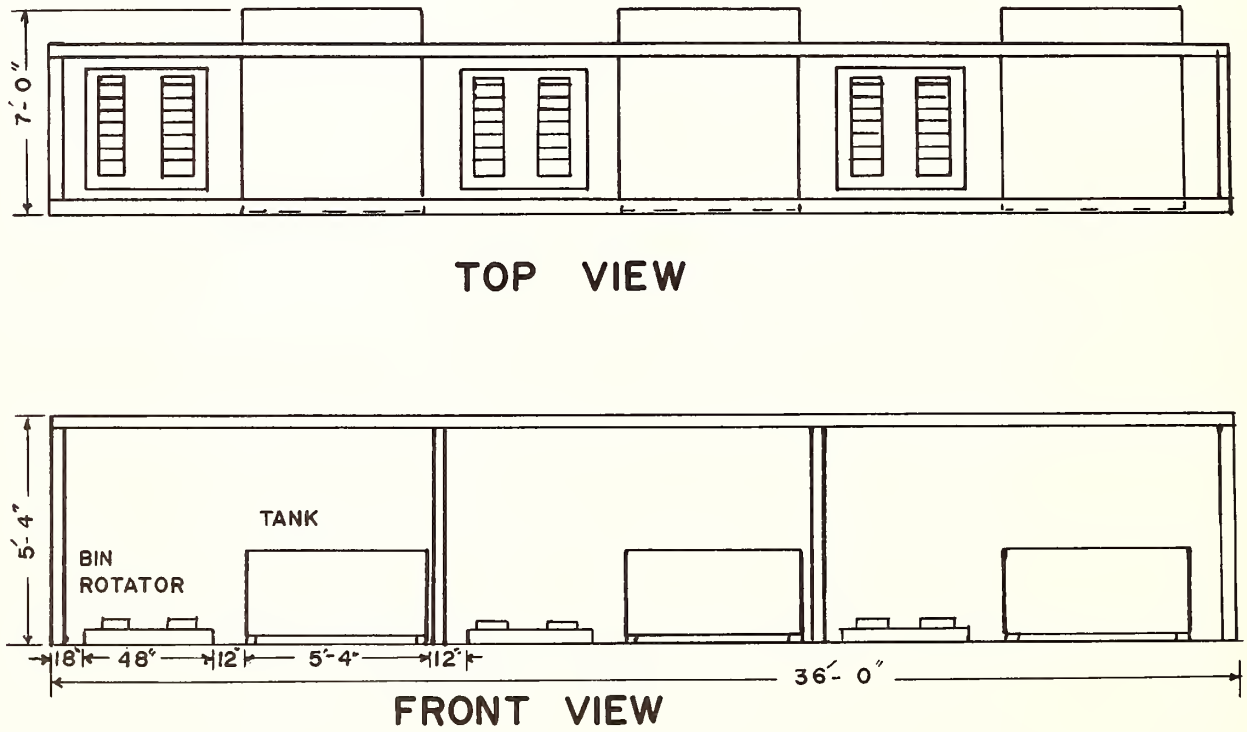

Figure 13.--Representation of possible 3-tank layout; area required is 36 by 7 feet.

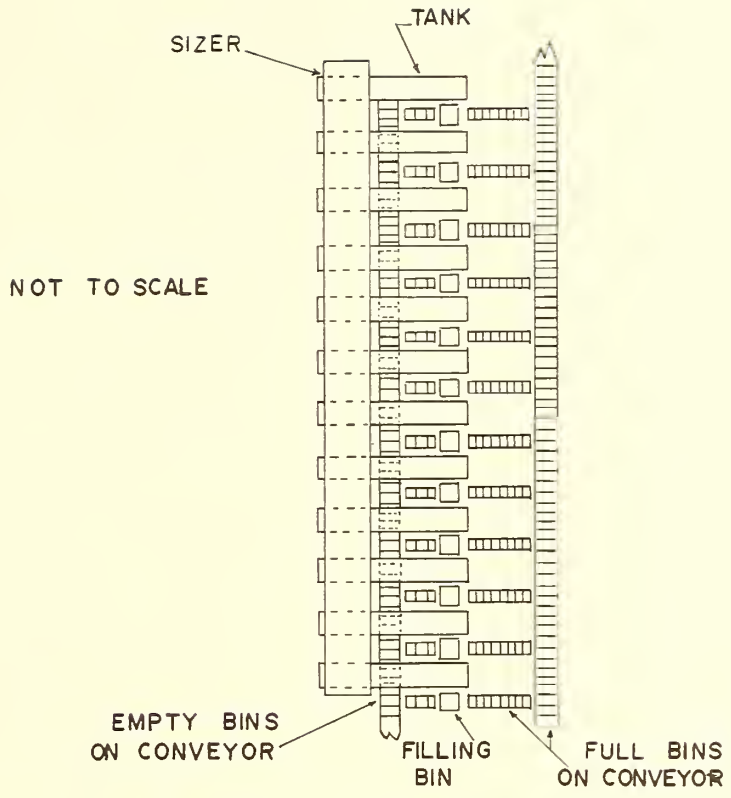

Figure 14.--Possible layout for 12-tank unit wet-dry bin filler where building is long and narrow; area required is 144 by 30 feet.

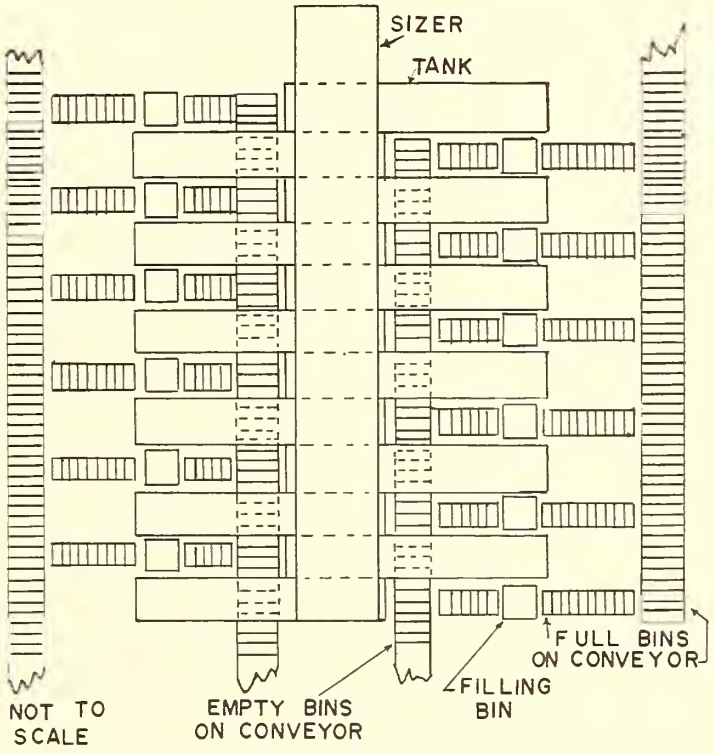

Figure 15.--Possible layout for 12-tank unit wet-dry bin filler where building is short and wide; area required is 56 by 72 feet.

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